DOCUMENT RESUME

ED 114 267 SE 019 166

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TITLE Findings and Implications of the Survey of Graduate Science Student Support from an NIH Point of View.
PUB DATE Mar 75
NOTE 24p.; Paper presented at the annual meeting of the American Educational Research Association (Washington, D.C., March 30-April 3, 1975)

EDRS PRICE MF-$0.76 HC-$1.58 Plus Postage
DESCRIPTORS *Doctoral Programs; Educational Finance; *Enrollment Trends; *Financial Support; *Graduate Study; Higher Education; Manpower Development; Science Education; *Surveys
IDENTIFIERS *National Institutes of Health; NIH

ABSTRACT

To the National Institutes of Health (NIH), the federal agency primarily responsible for the conduct of biomedical research, the Survey of Graduate Science Student Support and Postdoctorals is important because it provides information concerning bioscience research manpower projections. To policymakers in NIH, the two main components of the survey enrollment and financial support are of great interest. This paper deals primarily with two assumptions which can be made concerning enrollment and financial aid: (1) first-year enrollment is a predictor of Ph.D. output, and (2) support affects both graduate enrollments and Ph.D. production. Data from the Survey of Earned Doctorates tend to provide a correlation for the first assumption, although the ratio of Ph.D.'s per 100 first-year graduate students has declined from 31.1 in 1961 to 25.0 in 1967. This factor may be a result of an increase in the time needed to complete the degree, for the survey is based on a six year time lag. The author also states that assumption two, although not as easily illustrated, appears to hold a positive correlation. (CP)

Session No. A-30



# FINDINGS AND IMPLICATIONS OF THE SURVEY OF GRADUATE SCIENCE STUDENT SUPPORT FROM AN NIH POINT OF VIEW

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Presented before the
American Educational Research Association

Washington, D.C.
March 30-April 3, 1975



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INTRODUCTION

Are we going to have enough excellent scientists in the future to carry forward our crusade against cancer, heart disease, arthritis, aging—to name just a few of the major health areas of concern today?

This question is of vital importance to all of us as potential beneficiaries of advances in health research, but it should be of particular concern to you as educators, educational researchers, and administrators who are concerned with both the quantity and quality of graduate output and the viability of the entire U.S. graduate education system. I can tell you that this question is a great concern to NIH, as the lead Federal agency charged with the conduct of biomedical research.

But what does all of this have to do with the Survey of Graduate Science Student Support and Postdoctorals, which I will henceforth refer to as the SGS survey? Well, dropping considerations of "excellence" and "adequacy," I believe that the two basic data elements of this survey, enrollment and student support, carry implications for projections of Ph.D. output, and therefore for projections of bioscience research manpower.

I want to do three things this evening. First, I want to discuss the assumptions that enrollment, specifically first-year enrollment, is a predictor of Ph.D. output; and that support affects both graduate enrollment and Ph.D. production. Second, I'd like to highlight for you the SGS data that relates to these assumptions. Lastly, I will have something to say about the significance of these data to those concerned with the future of health research.

ASSUMPTIONS:

Use of the link to graduate enrollment, particularly first-year enrollment, as an indicator of future Ph.D. output, is practically a tradition in spite of the two obvious reasons why the link is diffuse. First, a significant though unknown proportion of graduate enrollment is for terminal master's degrees (planned or otherwise). This is less of a problem in the biosciences than in some other fields. Second, the lapsed time from the bachelor's degree to Ph.D. is variable across a broad range—about half of the candidates taking 3 to 7 years and half taking more than 7 years. However, the distributions involved are stable enough that first-year enrollment, appropriately lagged, is highly correlated historically with Ph.D. output in the biosciences.

The relationship of outside financial support—Federal or other—of the graduate student to graduate enrollment and Ph.D. production is another matter. Establishment of this relationship has proved curiously elusive. Longitudinal studies of student population cohorts, for example, have not isolated outside financial support as the significant factor in enrollment or in degree completion. There have been some reasonably successful statistical studies that can be cited, however, that tend to confirm the hypothesis that such financing is critical.

A 1962 study by James A. Davis found a relationship between holding a job and slow academic progress or dropping out.[1]

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[1]Davis, James A. *Stipends and Spouses: The Finances of American Arts and Science Graduate Students.* Chicago. University of Chicago Press, 1962.

A 1963 study by Warkow, Briskie, and Berger found that part-time employment was a factor in delayed progress.[2] Holmstrom and Sharp's study of NDEA fellowships in 1970 found that fellowships shortened the duration of doctoral study by making part-time study unnecessary.[3]

The continual methodological problem, however, that has plagued researchers, is that the demonstrated relationships between financial arrangements and progress do not adequately indicate what is cause and what is effect. In short, it is not obvious whether people go to school because they are financed or are financed because they go to school.

A recent study, being performed under contract to NIH, does provide empirical evidence that support, in particular Federal support, has impacted graduate enrollment and Ph.D. output in the biosciences. This study first examines graduate enrollments and Ph.D. degrees conferred relative to the population age group 20-24 and bachelor level degrees, and finds that these demographic factors have not predominated. The study then investigates four economic factors and finds them to be significant explanatory variables for graduate enrollment and Ph.D. completion in the biosciences. The factors taken into consideration were:

1. salaries of college graduates relative to non-graduates,
2. Federal financial support for students in higher education,
3. aggregate personal income, and
4. Federal funds for research and development.

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[2]Warkow, Seymour, Bruce Briskie, and Alan S. Berger. *Graduate Students Finance, 1963*. Chicago. National Opinion Research Center, September 1965.

[3]Holmstrom, Engin I., and Laure M. Sharp. *Study of NDEA Title IV Fellowship Program, Phase II*. Washington, D.C. Bureau of Social Science Research, Inc., July 1970.

The conclusion of the study is:

> "When these variables (to the extent that they are available) are examined in relation to the trends in degrees and enrollments, the empirical evidence points to the conclusion that federal aid to students in graduate education has had the greatest influence on degree and enrollment ratios followed by income variables and expenditures for research. Income seems to have its greatest impact on the ratio of BA's to population age 20-24, while federal aid to graduate students has a strong influence on the proportions enrolling in graduate school and obtaining PhD degrees."

Another study funded by NIH within the Office of Scientific Personnel of NRC and conducted by Professor Robert McGinnis from Cornell University, examined the relationship between Federal expenditures for research and the number of doctorates awarded in science and engineering fields by U.S. universities.[4] Dr. McGinnis found that doctorate production in science and engineering was a nearly perfect linear function of Federal research expenditures, with a lead time of 5 to 6 years, at least during a period when research expenditures were growing. We have no extensive experience with declining research expenditures.

The McGinnis study also related several series of NIH awards to graduate programs in four fields—biochemistry, genetics, pharmacology, and physiology. The data of Table 1 shows relations observed between number of graduate students and of doctorates awarded and various aspects of NIH funding. The funding categories shown have very instructive characteristics. "NIGMS (National Institute of General Medical Sciences) training funds, four fields" were support awarded specifically for the four fields. "NIGMS training funds to institutions" add in all other NIGMS funds. "NIH funds to institutions"

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[4] McGinnis, Robert. *Federal Funding and Graduate Education in Bioscience*. Office of Scientific Personnel, National Research Council, February 1972. Unpublished.

TABLE 1

CORRELATIONS BETWEEN SELECTED MEASURES OF NIH AWARDS AND NUMBER OF GRADUATE STUDENTS AND DOCTORATES AWARDED IN FOUR FIELDS OF BIOSCIENCE*

| Selected measures | Graduate students Fall 1967 | | Doctorates awarded | |
|---|---|---|---|---|
| | First year | Intermediate and terminal years | 1959-1963 | 1964-1968 |
| Total NIGMS training funds, four fields, 1968 | .56 | .80 | .64 | .74 |
| Total NIGMS training funds to institutions, 1968 | .40 | .58 | .55 | .63 |
| Total NIH funds to institutions, 1968 | .22 | .45 | .43 | .50 |

*Biochemistry, genetics, pharmacology, and physiology.

Source: Robert McGinnis. *Federal Funding and Graduate Education in Bioscience*, Table 8 (unpublished). National Research Council/OSP, Washington, 1972.

add in all other funds from the NIH. In short, the categories of funds ascend from the specific to the general, while the fields of science remain the same. Funding data for 1968 are used with the well-grounded assumption that the funds awarded to these institutions in 1968 are highly correlated with funds awarded in prior years.

The correlations displayed in Table 1 suggest several conclusions. First, for each column there is a gradient in the funding correlations, the strongest relationship appearing with funds specifically awarded for training in the four fields in which the students were being trained, the weakest with the general total of all NIH funds awarded to the institutions. Second, the higher retention of students up to the point at which they eventually receive the doctorate appears to be a significant advantage of training grants. Although the data do not, of course, prove the point, they suggest that given the availability of a range of funding mechanisms, training grants are most efficient both in attracting graduate students into a field and, more importantly, in retaining them in the field for the time required to atain a doctorate.

THE DATA—GRADUATE ENROLLMENT AND Ph.D. OUTPUT:

Now let's take a look at the data that are available. The NSF survey provides a 7 year time series for the sciences in general, but it only provides three years of enrollment (1971-1973) and two years of support information for the biosciences—the area of science of primary concern to NIH. The early data presented by Ms. Foster were collected as part of the NSF traineeship application, and, as such, are not felt to be representative of the bioscience programs which were being supported, predominately, by the NIH. As a result, I have relied on Office of Education data for the period 1961-1970 to set the necessary background for the SGS data, and the National Academy of Sciences, National Research Council, Survey of Earned Doctorates, for information pertaining to past production of Ph.D. bioscientists.

Table 2 shows that first-year, full-time enrollment in the biosciences doubled between 1961 and 1966, averaging about 15 percent per year. Between 1967 and 1973, first-year, full-time enrollments increased, though at the greatly reduced rate of about 3 percent per year. I have used OE and SGS data for 1971 to estimate a link between the OE and SGS series.

The NSF-Quick Response Survey for 1974 has yielded a surprisingly large estimate of increase in first-year, full-time bioscience enrollment of 24 percent. I tend to believe the 24 percent estimate is too high. It is the largest single increase in the last 13 years, and the 95 percent confidence range is itself virtually 24 percent.

Table 2

FIRST-YEAR, FULL-TIME ENROLLMENT IN THE BIOSCIENCES
1961-1974

| Year | Number | Annual percent change | Percent change since 1961 |
|---|---|---|---|
| 1961 | 4,634 | | |
| 1962 | 5,084 | 9.71 | 9.71 |
| 1963 | 5,973 | 17.49 | 28.90 |
| 1964 | 7,361 | 23.24 | 58.85 |
| 1965 | 8,486 | 15.28 | 83.12 |
| 1966 | 9,310 | 9.71 | 100.91 |
| 1967 | 9,528 | 2.34 | 105.61 |
| 1968 | 9,475 | -.60 | 104.47 |
| 1969 | 10,077 | 6.35 | 117.46 |
| 1970 | 10,449 | 3.69 | 125.49 |
| 1971 | 10,934 | 4.64 | 135.95 |
| | Estimates | | |
| 1972 | 11,249 | 2.88 | 142.75 |
| 1973 | 11,428 | 1.59 | 146.61 |
| 1974 | 14,227 | 24.49 | 207.01 |

Sources: 1961-1971—*Students Enrolled for Advanced Degrees.* U.S. Office of Education.

1972-1973—Estimates were developed by applying the trend obtained from the NSF *Survey of Graduate Science Student Support and Postdoctorals* to O.E. data.

1974—Estimates were developed by applying the change, 1973-1974, obtained from the NSF *Quick Response Survey of Graduate Enrollment* to the 1973 estimates.

The question of real importance here is not whether there was a large jump in 1974 but whether a '74 increase presages another major growth spurt in the long term trend line. Only time will tell for sure, but those concerned with assessing future research manpower resources can't wait for the answer before attempting to evaluate future Ph.D. output.

Relating graduate enrollment data to Ph.D. output (Table 3) assuming a six year lag between first-year enrollments and Ph.D. completion[5] reveals that the ratio of Ph.D.'s to first-year enrollments has declined from a high of 35 per hundred in 1968 to the 1973 figure of 25 per hundred, despite the fact that the average lapse of time between B.A. and obtainment of the Ph.D. has not changed significantly for some years. The change in this ratio, though not proof of anything, may be used as an indicator that non-Ph.D. outcomes, including terminal Master's production, have increased or, viewed another way, that students are making slower progress towards obtainment of the Ph.D.

I want to emphasize here the significance of these phenomenon. The key to reasonably accurate projections of biomedical research manpower is attrition rates. The final outcome, that is, estimates of the present and future supply of biomedical researchers, is dominated by estimates of attrition:

1. from first-year enrollment to Ph.D. output,
2. from each Ph.D. class to entry into the research pool, and
3. from the research pool into non-research activities.

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[5]The median total time lapse from baccalaureate to doctorate in the biosciences was 5.9 years. *Summary Report 1973 Doctorate Recipients from United States Universities*, National Academy of Sciences. Washington, D.C. May 1974.

TABLE 3

RATIO OF PH.D.'S IN THE BIOSCIENCES PER 100 FIRST-YEAR GRADUATE ENROLLEES IN THE BIOSCIENCES, 1967-1973

| First-year graduate enrollment | | Ph.D. output lagged six years | | Ratio of Ph.D.'s per 100 first-year graduate students |
|---|---|---|---|---|
| Year | Number | Year | Number | |
| 1961 | 7,699 | 1967 | 2,398 | 31.1 |
| 1962 | 8,196 | 1968 | 2,882 | 35.2 |
| 1963 | 9,745 | 1969 | 3,138 | 32.2 |
| 1964 | 11,821 | 1970 | 3,418 | 28.9 |
| 1965 | 13,608 | 1971 | 3,699 | 27.2 |
| 1966 | 14,200 | 1972 | 3,672 | 25.9 |
| 1967 | 14,874 | 1973 | 3,719 | 25.0 |

Sources: First-year enrollments, 1961-1967: *Students Enrolled for Advanced Degrees*, U.S. Office of Education.

Ph.D. Degrees, 1967-1973: *Survey of Earned Doctorates*, National Research Council, National Academy of Sciences.

Using the data available to illustrate this point, let's assume that the 35 per hundred ratio of Ph.D.'s in 1968, lagged to first-year enrollment in 1962, had been projected forward as a constant for the period 1969-1973. The resultant estimates of Ph.D. production during this period would have been 22,487, or 27 percent higher than was the actual Ph.D. production of 17,646. If there were a similar error in the other two estimated attrition rates mentioned, a compounded error of the order of 65 percent would result.

Clearly then, accurate assessment of attrition rates and the factors affecting them is essential—which leads us to the implications of the NSF survey of graduate student support data.

THE DATA—GRADUATE SCIENCE STUDENT SUPPORT PATTERNS

The NSF survey, though limited to a very short period of time, provides a direct assessment of patterns of bioscience student support showing type and source of support by enrollment level. The following observations can be made from the SGS survey.

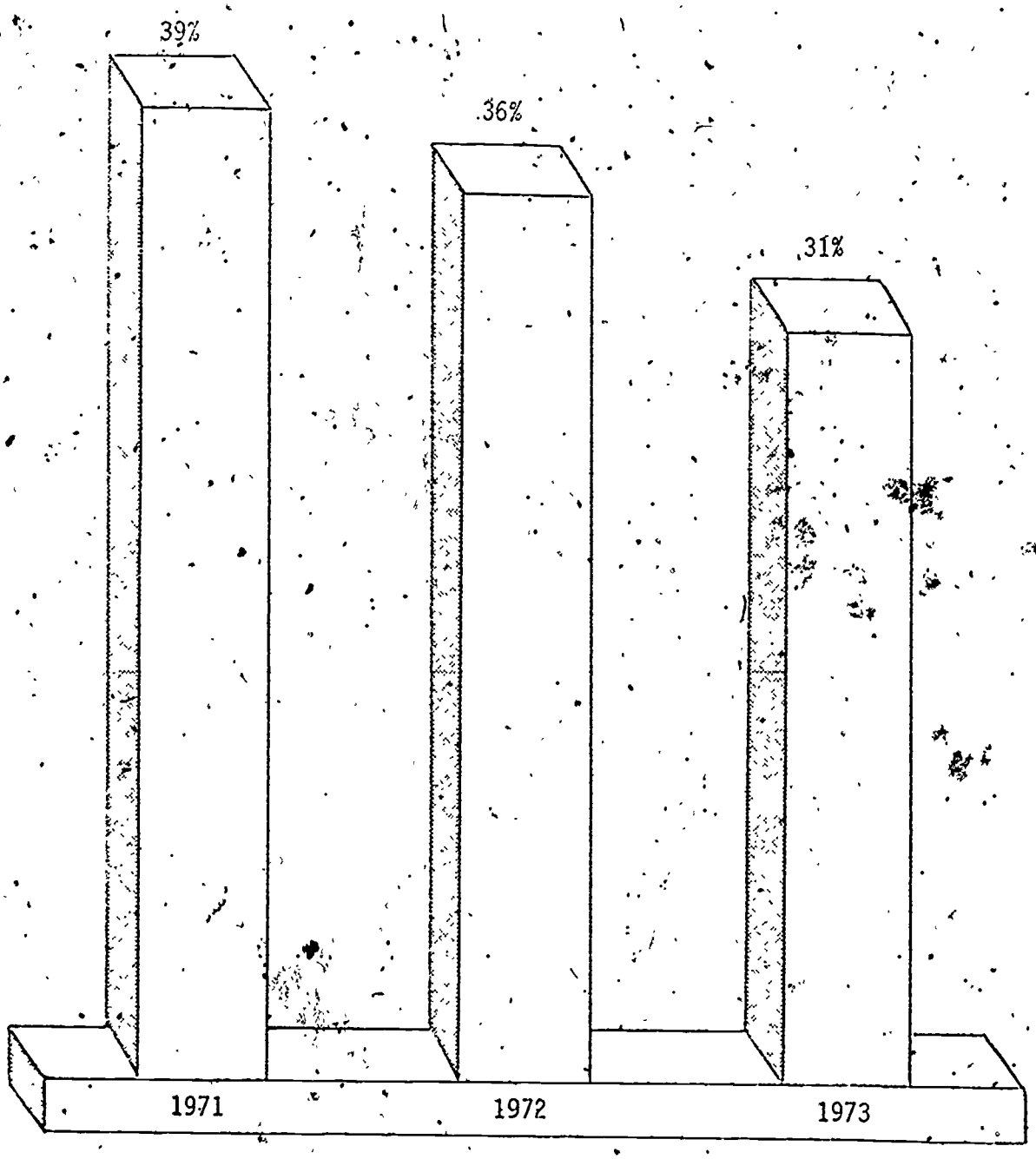
1. The proportion of all full-time bioscience graduate students receiving Federal support has declined from 39 percent to 31 percent, a 22 percent decrease over the period 1971-1973 (Chart 1).
2. Despite the decline in Federal support in the biosciences the same percentage of bioscience students were "self-supporting" in 1972 and 1973. Additional non-Federal funds were forthcoming to offset the decline in Federal support. Unfortunately, this type of survey cannot distinguish non-Federal public support, institutional funds support, and other sources of general revenue (Chart 2).
3. Students directly supported, that is, students receiving fellowships and traineeships, declined 10 percent, 1972-73, caused by a decline from Federal sources which was offset to some extent by increases in non-Federal sources (Chart 3).
4. Students receiving support as research assistants increased slightly (+4 percent); essentially no change in the Federal sector, and a 9 percent increase from "non-Federal" sources (Chart 4).

5. Bioscience students on teaching assistantships increased 7 percent, the gain coming entirely from the non-Federal sector. This may be traceable to increased undergraduate enrollment in the biosciences (Chart 5)./.

6. Earlier in this paper, I have stressed the importance of first-year enrollments as an indicator of future Ph.D. output. The SGS survey has source of support data for first-year bioscience students only for the year 1973. It does provide a two-year trend of first-year enrollments by type of support. The graph indicates that first-year bioscience students have taken the brunt of declines in direct training support, exemplified by fellowships and traineeships, which is primarily a reflection of the declines in Federal support (Chart 6).

Chart 1

PROPORTION OF FULL-TIME BIOSCIENCE STUDENTS
RECEIVING FEDERAL SUPPORT: 1971-1973




Source: *Survey of Graduate Science Student Support and Postdoctorals*, National Science Foundation.

Chart 2

PERCENT DISTRIBUTION AND PERCENT CHANGE
IN FULL-TIME GRADUATE STUDENTS IN THE BIOSCIENCES,
BY SOURCE OF SUPPORT, 1972-1973

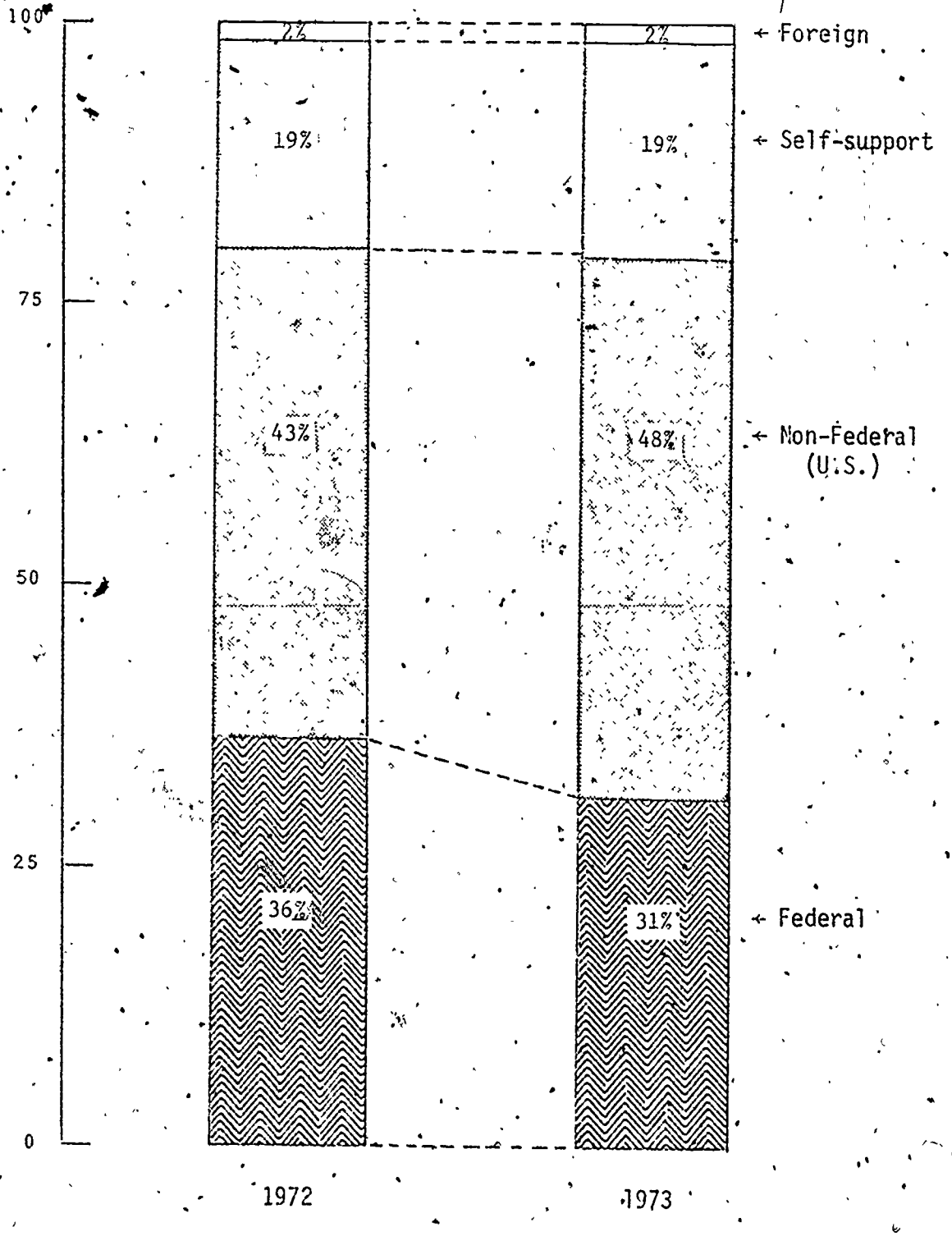
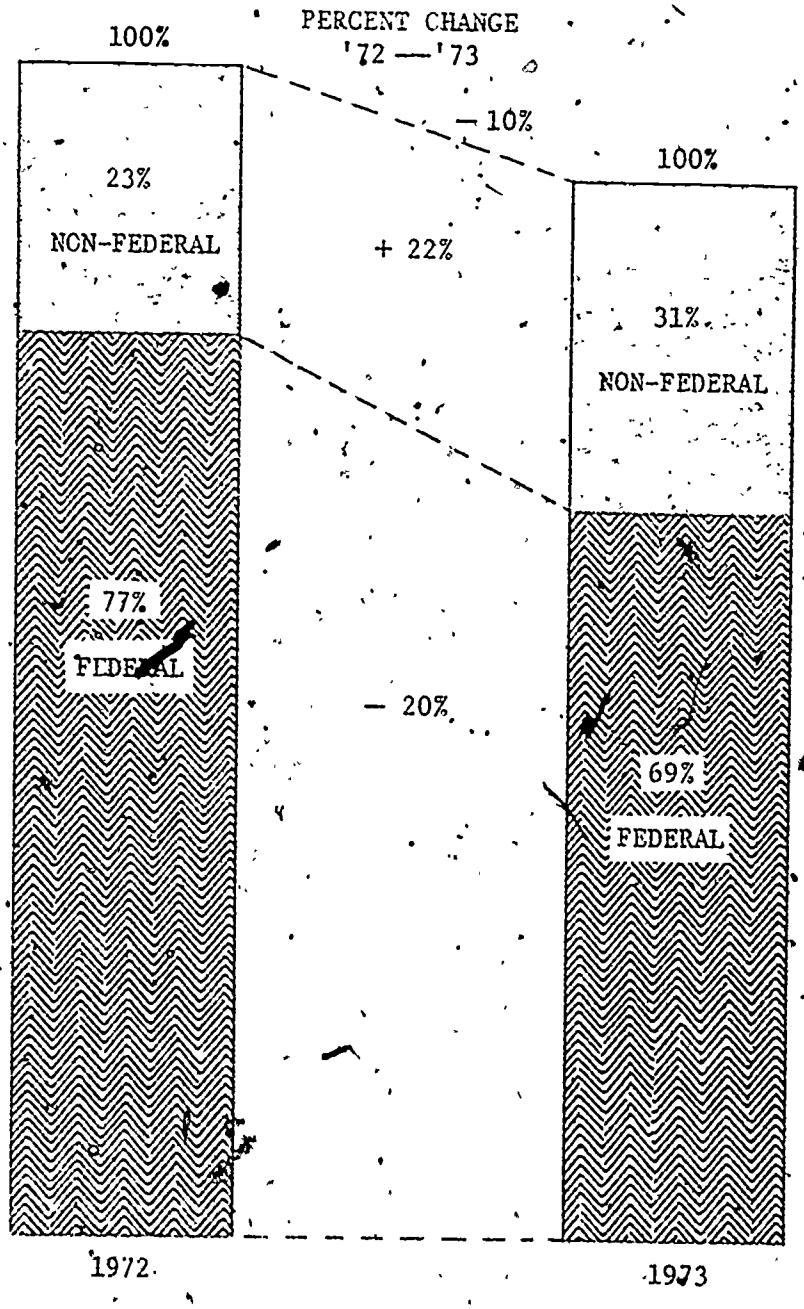


Chart 3

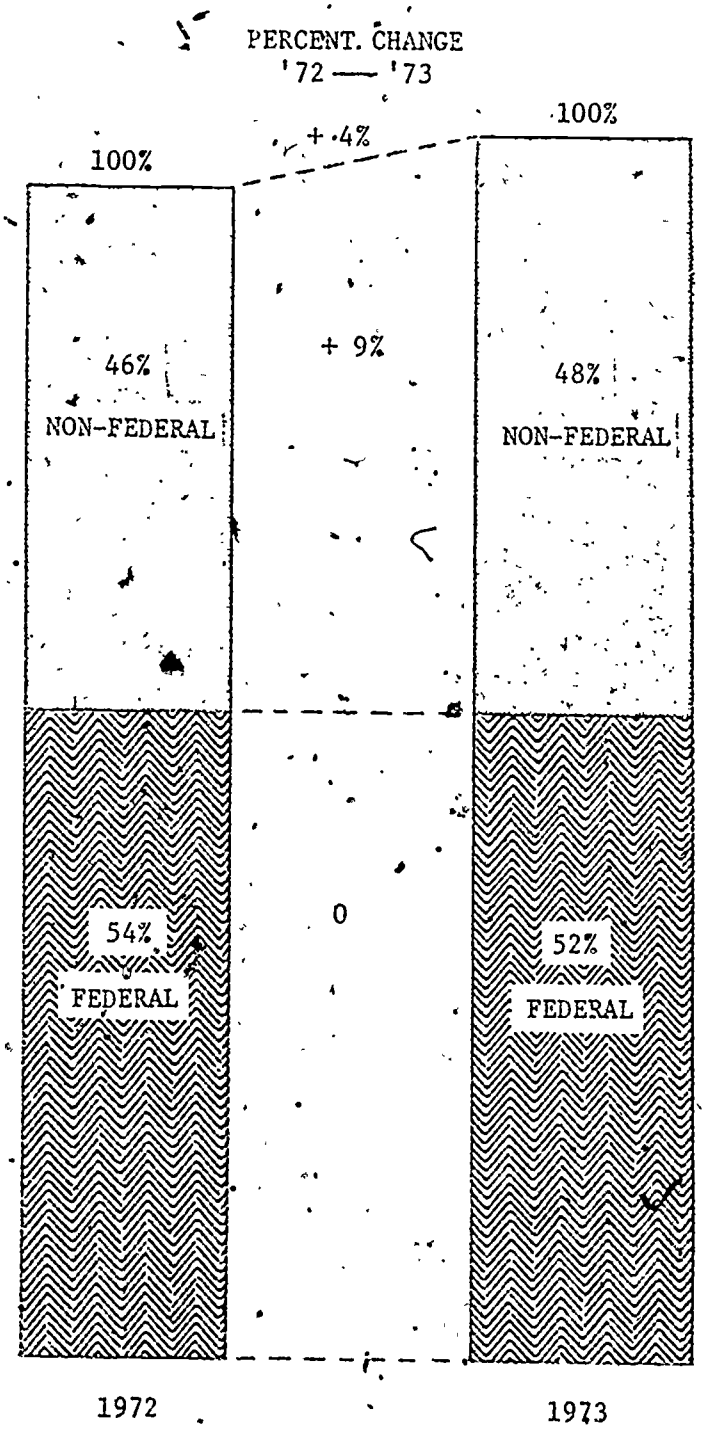
FULL-TIME BIOSCIENCE GRADUATE STUDENTS RECEIVING TRAINEESHIP AND FELLOWSHIP SUPPORT, BY SOURCE, 1972 AND 1973




Source: *Survey of Graduate Science Student Support and Postdoctorals.*

Chart 4

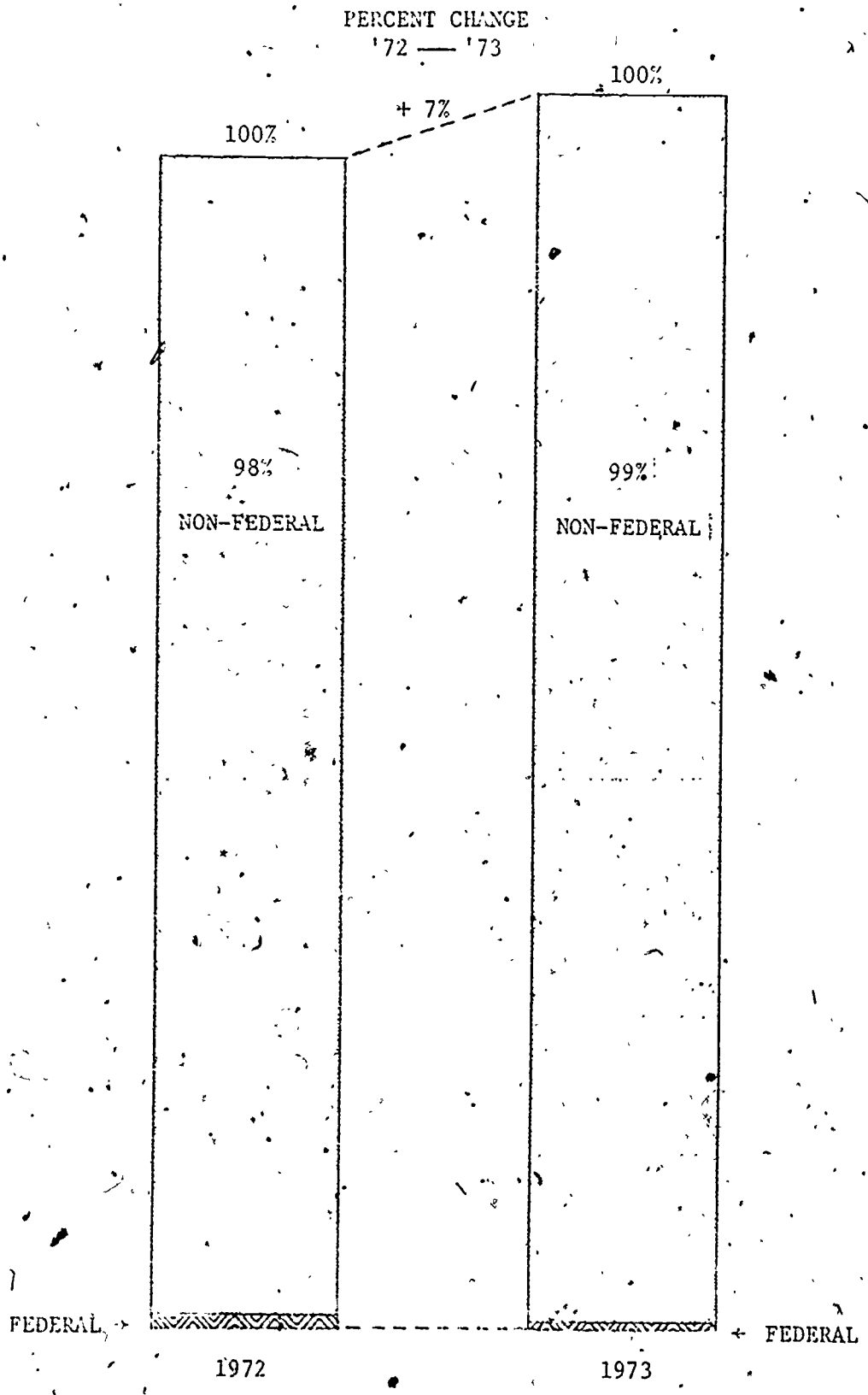
FULL-TIME BIOSCIENCE GRADUATE STUDENTS RECEIVING RESEARCH ASSISTANTSHIPS, BY SOURCE OF SUPPORT, 1972-1973




Source: *Survey of Graduate Science Student Support and Postdoctorals.*

Chart 5

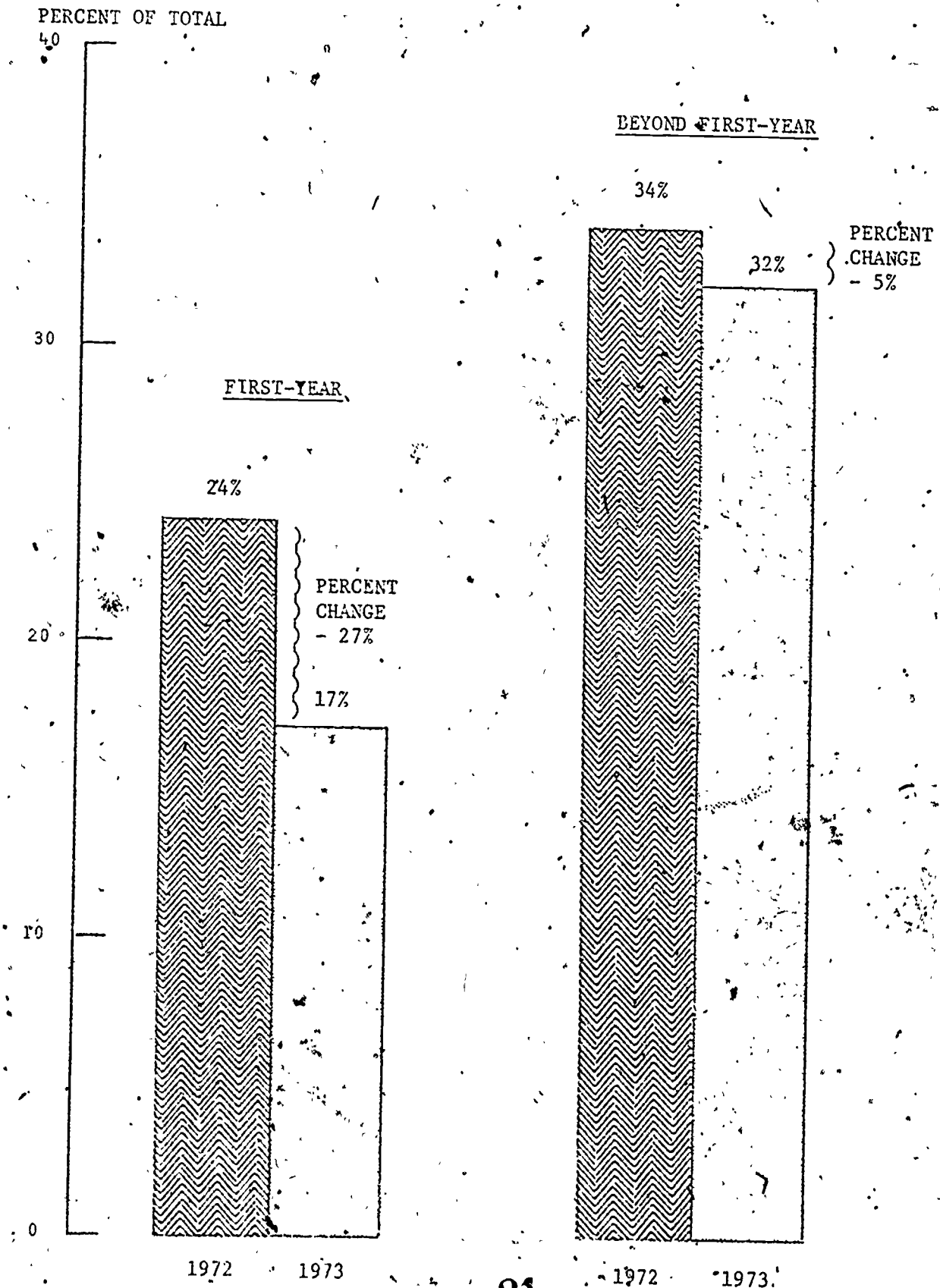
FULL-TIME BIOSCIENCE GRADUATE STUDENTS RECEIVING TEACHING ASSISTANTSHIPS, BY SOURCE OF SUPPORT, 1972 AND 1973




Source: *Survey of Graduate Science Student Support and Postdoctorals.*

Chart 6

FULL-TIME BIOSCIENCE GRADUATE STUDENTS RECEIVING TRAINEESHIP AND FELLOWSHIP SUPPORT, BY LEVEL OF STUDY, 1972 AND 1973



IMPLICATIONS

This is the recent picture of graduate student support and enrollments in the biosciences. I began this paper by defining our concern as: the implications of the SGS survey for projections of Ph.D. output. We approach the end of the paper with a collection of questions. What is likely to be the follow-on support picture for all those eager, hopeful first-year enrollees of the early seventies? Will they have obtained the Ph.D. by 1980 at close to the same rate as those who entered before them? Will more be required to drop out because of the inability to meet the rising financial demands concomitant with their stage in life plus ever higher educational costs, or simply slow down the Ph.D. process by working on an outside job while going to school and writing dissertations? Will first-year graduate enrollments continue to increase?

As far as the evidence is concerned, that is, in summary:

1. declining growth in first-year enrollments assuming the 1974 jump is an aberration produced by the economic conditions of the day and not indications of another growth spurt brought about by environmental and ecological concerns,
2. declining ratios of graduate enrollments to Ph.D. output,
3. declining levels of direct Federal training support,

plus knowledge of the modest growth in the graduate school age population, those 21-24, 1973-1981, of 14 percent, followed by a decline, 1981-86, of 5.5 percent, lead one to anticipate a continued level of

Ph.D. output in the near future followed by declines. Translated into NIH terms, this implies a reduction in the availability of new Ph.D. bioscientists to conduct medical research.

I have limited this discussion purposely to the question of availability of new Ph.D.'s for the conduct of biomedical research for that is the question that can be addressed most readily with the use of SGS.

But underlying this question is, of course, such questions as: Is there presently and will there in the future be a shortage of biomedical researchers? I would like to point out that there is no natural requirement for research manpower. The demand is purely a function of the level of research activity which society chooses to support which may call for more or fewer researchers than are in the pool.

If the Government, through the operation of the legislative and executive branches, determines that a particular level of health research activity is desirable and supplies a level of funding to carry it out, but there is not an adequate number of trained researchers to assume this level of activity, then there is a shortage. In recent discussions relative to the new cancer initiative, it was clearly recognized that manpower is a critically limiting factor at the present time and will continue to be in the future.

I have addressed one small aspect of forecasting the supply of future bioscientists and have indicated the role played by the NSF survey and other educational surveys in the development of such

forecasts. In closing, I would like to say that without the continued help of the educational community in providing these and other data and the contributions of educational researchers, even this limited analysis would not have been possible. For your help in the past, I thank you, and I look forward to the future insight which you will provide.

Thank you.